Progress Report

Mini-Solar Power Station

SD1203

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1. Objectives

The Mini-Solar Power Station will consist of two subprojects. The first subproject will be to construct a satellite tracking system. The Satellite Tracker will contain a max satellite dish covered with a reflective Mylar material, but it will also be convertible to allow for a solar panel to be easily installed. The satellite dish will track the sun ensuring that a maximum amount of sunlight will be collected at all times. When the dish does not have the solar panel installed, the reflective Mylar material will focus all the sunlight to the dish's focal point. A hollow copper coil tube, which contains continuously running fluid, will be placed at the focal point. As the sunrays are reflected and focused at the copper coil tube, essentially at one point, the copper coil will begin to heat up which will consequently heat the fluid inside the coil. Thermal insulated tubing will connect the copper coil to a heat exchanger, so that the heat from the liquid can be measured. Using an NI USB 6008 DAQ, the temperature data will be plotted in real time using LabVIEW. When the solar panel is installed, the energy obtained will charge two 12-volt batteries. The batteries will run a 300-watt inverter so common household appliances can be used. Satellite motor operation will be controlled using a PIC microcontroller, and will be coded in C.

The second subproject includes constructing a mechanical fixture containing a heat/light source to simulate the rising, setting, and latitudinal movements of the sun. The fixture will be composed of 1" EMT, a combination of pulleys, stepper motor, and a linear actuator to drive the heat bulb to mimic the suns movement. The fixture will be used in correspondence with the above-mentioned satellite dish and serve as a testing device to prepare the Satellite Tracker for operation outside. A 250W infrared heat lamp will be used to represent the sun and will be the source of heat. A dimmer switch will used with the heat lamp, which will dim the heat lamp to represent cloud cover. The dimmer switch will be controlled using the PIC and Pulse Width Modulation (PWM). As stated above, temperature data will be collected and plotted in LabVIEW. With the dimming of the lamp, the decrease in temperature should be evident in the LabVIEW plotted data. Both motor control and dimmer switch will be controlled by a PIC microcontroller, and programming will be done using C. The final goal of the project is to have the mini-solar power station fully functional outside using natural sunlight.

2. Current status and obstacles

We believe we have gained considerable ground on our project in the first half of the semester. We have bread boarded a working tracking system using a comparator, 3 photocells, and the PIC. The photocells are used to detect the sunlight. A comparator is used to decide which photocell is receiving the highest amount of light. The middle photocell serves as the "zero" point, so when this photocell is receiving the largest amount of sunlight the satellite dish is in the correct position and is receiving the largest amount of sunlight. When the middle photocell is receiving the highest amount of sun the satellite dish will not move. However, if the left photocell is read to have higher sunlight, the dish will move left until the middle photocell is receiving the highest amount of sunlight. The tracking system will continuously compare the photocell values so that maximum sunlight is always obtained. The final assembly will include more than three photocells; most likely it will have a total of 5 photocells forming a cross pattern. Our prototype only represents horizontal movement, so adding one photocell on top and bottom of our current middle photocell will provide comparison for vertical movement.

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The sun simulator also has made considerable progress. Using a stepper motor, linear actuator, keypad, PIC, and driver circuitry we have a complete prototype for motor control. Using a series of pulleys, the stepper motor will essentially be used to "push" and "pull" the heat lamp to mimic longitude sun movement. The linear actuator will be used to add ±15 degrees (from the starting point), thus mimicking latitude movement. The sun speed will include 3 different settings. The slow setting will be used to mimic an 8 hour day of sunlight (from sunrise to sunset). The medium setting will allow the system to run for 1-2 hours. Finally, the fast setting will allow the system to run in 5-10 minutes. The slow setting will mostly be used to collect temperature data and determine optimal power absorption of the solar panel. The medium and fast speeds will be used to test the accuracy and ability of the satellite tracking system. The fast setting will also be used for demonstration purposes. Also, the sun simulator has three angle settings. The first setting will shift the simulator 15 degrees "up" from the neutral position, the second setting will not move the simulator, and the third setting will shift the simulator 15 degree "down" from the neutral position. The LCD screen displays the following information at the start of the simulation:

"SD1203: Sun Simulator"
"Enter Speed and Angle"
"Heat Lamp Speed: 1-3"
"Heat Lamp Angle: 4-6"

To start simulation, the user must enter a speed and an angle. For example; if the user enters 1 and 4 the simulation will run on slow setting 15 degrees "up" from neutral position, and if the user enters 3 and 5 the simulation will run at medium speed in the neutral position (does not move up or down). Once the user enters a speed and angle the LCD screen displays the following information:

"You Selected 'speed' & 'angle'"
"   After Simulation   "
"Select another Speed"
" and Angle Setting   "

Where 'speed' and 'angle' is the keypad buttons the user has selected.

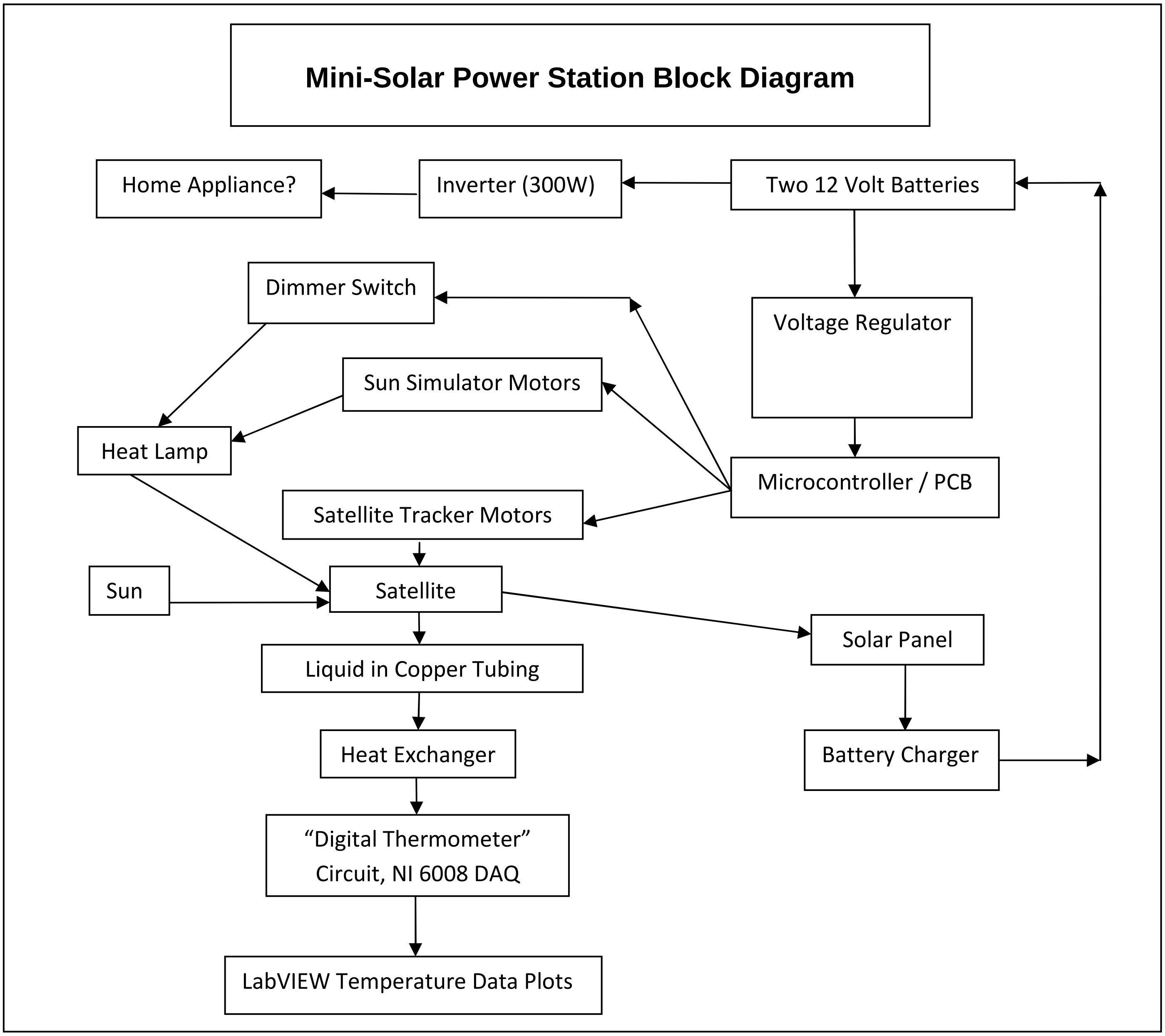
Our group has run into a pretty big obstacle. Our projects unique aspect was to harness the suns energy, in the form of heat, and using a Stirling engine we intended to convert the heat to electricity. After extensive research the Stirling engines we found available were very limited and/or very expensive. The Stirling engines that could of possibly worked for out project was in the price range of $300-$1200. The Stirling engines that would fit into our budget were hobbyist toys, and are used for demonstration purposes in schools. We contacted Steve Johnson from NDSCS Haas department to see if we could borrow or purchase (for the department) a Stirling engine, but found out the engines they build and use are basically the toy engines we found in our research. Although he was very accommodating and willing to help, the engines would not be able to serve our purposes. He said there are Stirling engine collectors and enthusiasts who would have an engine to meet our needs, but they would probably not let us use it because the engines are historic collectors' items and are worth thousands of dollars.

Our grouped liked how our project was taking the suns energy and converting it into electricity, so we researched another method to accomplish this. We researched thermoelectric cells which can be used to heat

and cool when a voltage is applied, or the device can produce voltage when there is a temperature difference. This is accomplished when heat is applied to one side and cooling is applied to the other side. This sounded really good until Dr. Yuvarajan mentioned these devices only produce voltage in mV range, which is not enough for our purposes. We are however still researching other unique methods that could be used to convert heat to electricity. Due to our obstacle, our project requirements have changed slightly. We will be using a solar panel to harness the suns energy and to create electricity. Although this method is not novel, it does have the advantage of not requiring any electrical energy or expenses to power them. In addition the solar panel requires little maintenance, mainly because there are no moving parts that must be maintained. Solar panels have been built to last a lifetime, so the solar station would pay great dividends. Also, solar panels do not cause any environmental pollution, plus installation and application of solar panels is suppose to be easy.

Other project updates include the ordering of mechanical parts for the sun simulator mechanical fixture and a few parts for the satellite tracker. These parts are shown in our updated budget below. The parts were researched and ordered to meet the initial design requirements. In addition, our SD1203 Wiki page was created and updated to reflect our current project objectives and goals. By the end of this semester our goal is to have both satellite tracking and sun simulator motoring finalized, have the dimmer circuit bread boarded and operational, and have made substantial progress on the sun simulator and satellite tracker mechanical structures. Also, we will be doing research and testing on the solar panel, NI USB 6008 DAQ, and LabVIEW. Once we receive the parts ordered we will begin building the dimmer switch and implementing the PWM code, with a completion date of April 20th. We have been working on circuit ideas for dimming the heat lamp, and decided to use a solid state relay and PWM using the PIC. In addition, from now and up until the end of the semester we will be researching mechanics and assembling both the sun simulator and satellite tracking structures. We believe we had made substantial progress in the first half of the semester and are on track to accomplishing our goals for the end of the semester and for the overall project.

3. Updated Block Diagram



4. Updated Budget

The Mini-Solar Power Station is budgeted on a single sun simulator and satellite tracking system. The budget includes cost of purchased material and an approximate cost of materials not purchased that will be used in our project, as well as a total approximation of the cost we expect to incur for this project.

Project Name:	Mini-Solar Power Station				
Project Number:	SD1203				
Sun Simulator					
Mechanical Hardware	Cost per Unit	Quinitity	Total Cost	Store/Supplier Part Number	Notes
Wheatland 1" x 10' EMT	$6.17	1	$6.17	Home Depot	
2x10 - 10'	$7.97	1	$7.97	Home Depot	
4 in Heavy Duty Tee Hinge	$3.87	2	$7.74	Grainger Industrial Supply	Part#: 1RCT3
R40 5" Dia., 250W, 120V Lamp	$21.84	1	$21.84	Grainger Industrial Supply	Part#: 1E295
Heat Lamp Dome	$18.00	1	$0.00		Provided by Jeff
Linear Actuator	$65.00	1	$65.00	Ebay	
57BYGH76-401A Stepper Motor	$60.00	1	$60.00	Ebay	Unipolar
Ball Bearing Sheave	$11.91	2	$23.82	Grainger Industrial Supply	Part#: 5RTD5
Flat Mount Block Pulley, 2"	$7.73	2	$15.46	Grainger Industrial Supply	Part#: 4JX69
Bearingless Sheave	$15.63	1	$15.63	Grainger Industrial Supply	Part# 5RRT4
1/16, 50ft, 7x19 stainless steel cable	$39.80	1	$39.80	Grainger Industrial Supply	Part#: 2TAY9
Solid State Relay	$30.00	1	$0.00	ECE Inventory	
Satellite Tracking System					
Mechanical Hardware					
Sattelite Dish	$50.00	1	$0.00	Direct TV	
Circular Base for Dish (Metal)	$20.00	1	$0.00		Provided by Jace
Mylar	$11.99	1	11.99	www.amazon.com	Part#: VMY130
57BYGH76-401A Stepper Motor	$60.00	2	$120.00	Ebay	Unipolar
5' Copper Pipe	$23	1	$23.00	Grainger Industrial Supply	
3' Insulated Plastic Tubing	$1.29	1	$1.29	Home Depot	
12V battery	$20.00	2	$40.00	Ebay	
NI USB 6008 DAQ	$169.00	1	$0.00	ECE Inventory	
Heat exchanger	$50.00	1	$50.00	Junk Yard	
Electrical Components					
ZTX1053a (npn transistor)	$0.98	20	$0.00	ECE Inventory	
MCP602 (OPAMP)	$0.62	16	$0.00	ECE Inventory	
PIC18F4620 (Microcontroller)	$7.92	5	$0.00	ECE Inventory	
ECS-200-20-46X (20 MHz Crystal)	$0.46	5	$0.00	ECE Inventory	
Photocell 80k-240kΩ	$1.86	15	$0.00	ECE Inventory	
LM7805 (5V voltage regulator)	$0.61	5	$0.00	ECE Inventory	
LM7812ACT (12V voltage regulator)	$0.69	2	$0.00	ECE Inventory	
Estimated Actual Cost of Project			$509.71		

5. Conclusion

The goal of this project is to create a functional satellite tracking system that is operational outside using natural sunlight. With the Mylar reflective material, the heat collected will heat liquid that will run through a heat exchanger. Temperature data will be plotted real time using LabVIEW, so decrease in temperature due to cloud cover should be easily recognizable. When the solar panel is installed, we intend to convert this energy into electricity to charge two 12-volt batteries. The 12 volt batteries will then run a 300-watt inverter, which will allow for use of household appliances. This approach will be fun and challenging, and it will require each group member to work independently and collaboratively, utilize previously learned information, and expand our technical competencies through research and development. The overall goal of the project is to have a fully functional mini-solar power station functioning outside using natural sunlight.